Assessment of Kinetic Energy as a Predictor of Injury Risk of Less Lethal Munitions

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Overview

- Introduction
- Background
- Study Design
- Results
- Discussion
- Conclusion
- Recommendations / Follow-On

Introduction

- Previous techniques
  - KE, Energy Density
- Kinetic Energy = $^{1}/_{2}mv^{2}$
- Energy density
  - kinetic energy/area of contact

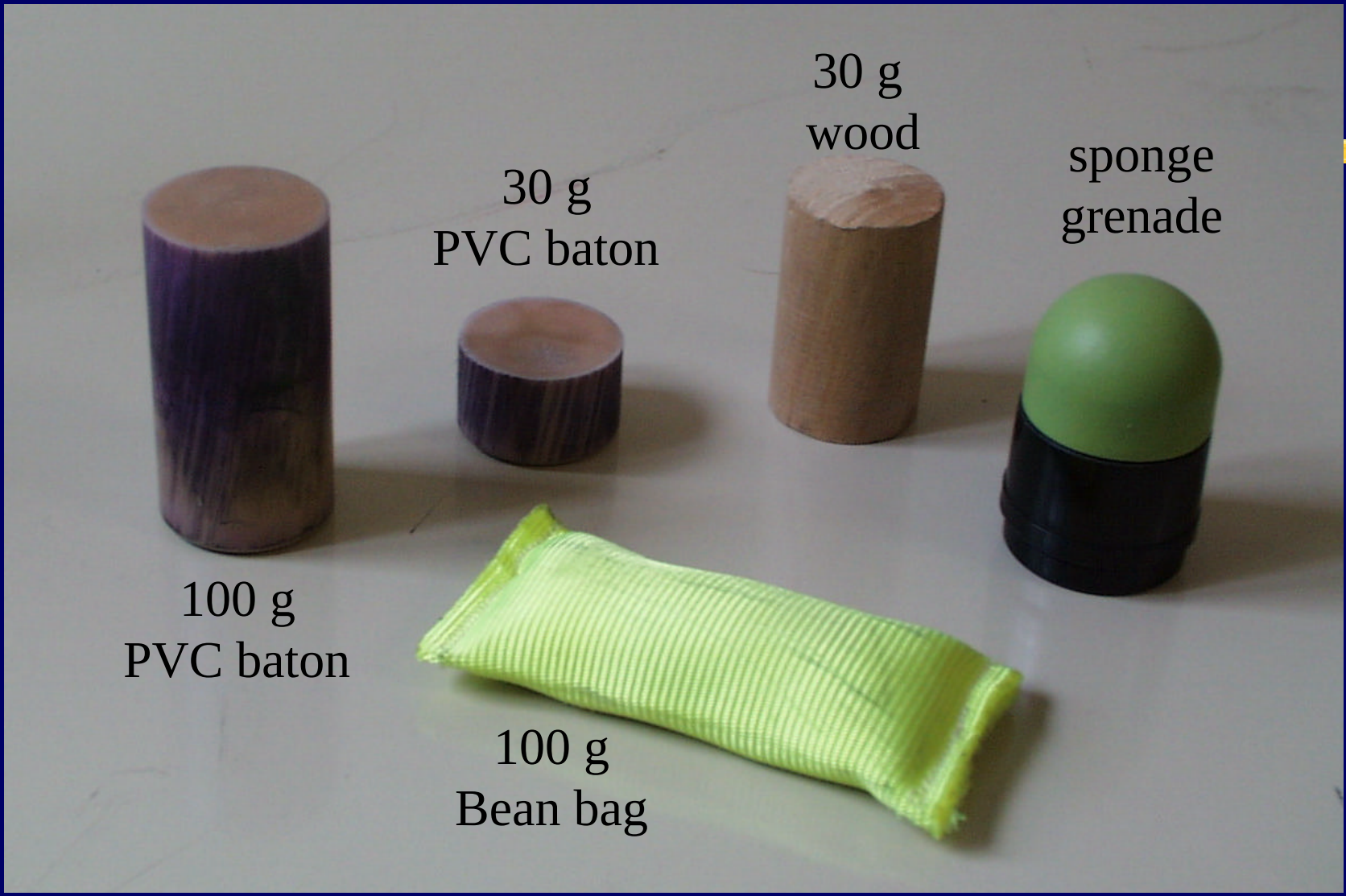
Background

- Platforms
  - 12ga., 37mm, 40mm
- Types
  - Rubber pellets, foam, wood and PVC Batons, bean bags
- Variables
  - Physical (velocity, mass, material, area of contact, # of projectiles)
  - Tactical (shot placement, distance)

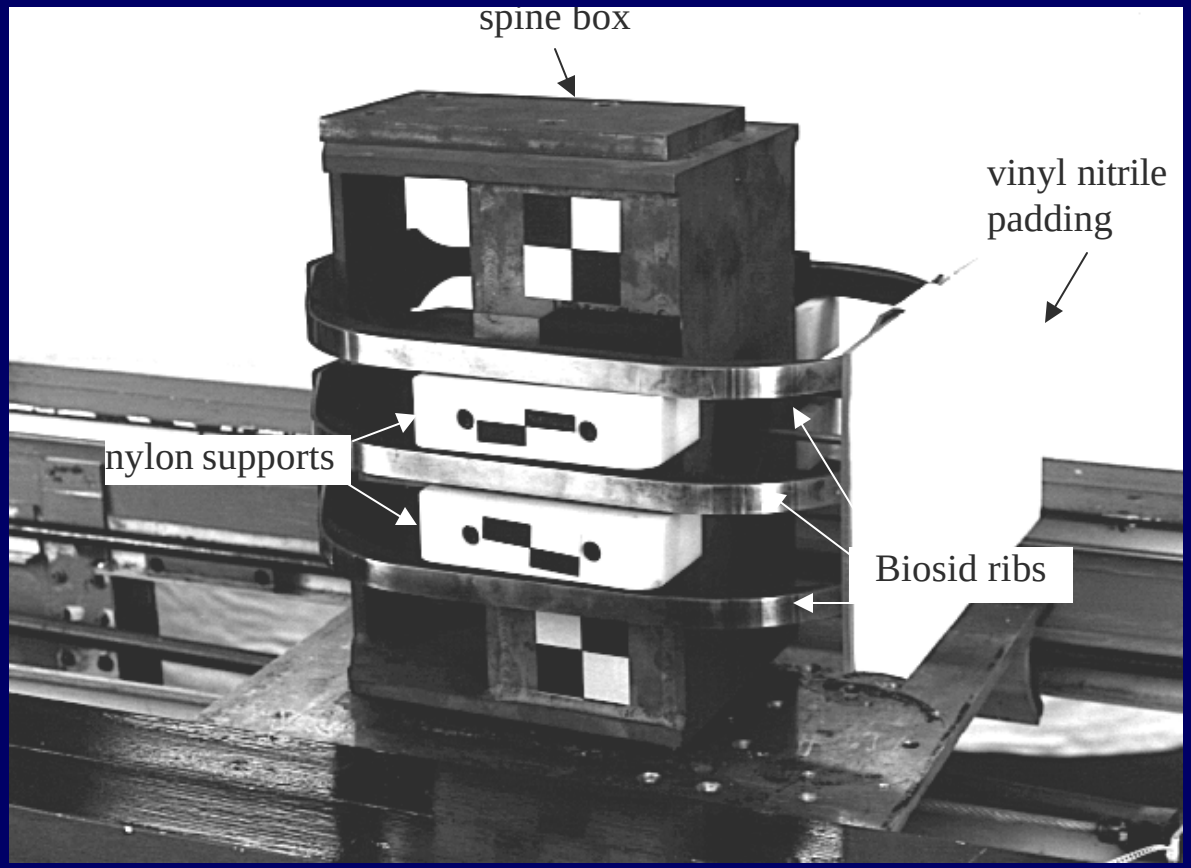
Less Lethal Munitions

Study Design

- Six Projectiles
  - PVC Baton (30g & 100g), 30g Wood, 100g Bean Bag, XM1006 (29g & 58g)
- Kinetic Energy
- Material and Mass Varied
- Injury Parameters


30 g
wood
30 g
PVC baton
sponge
grenade
100 g
PVC baton
100 g
Bean bag

3 Rib Chest Structure (3-RCS)



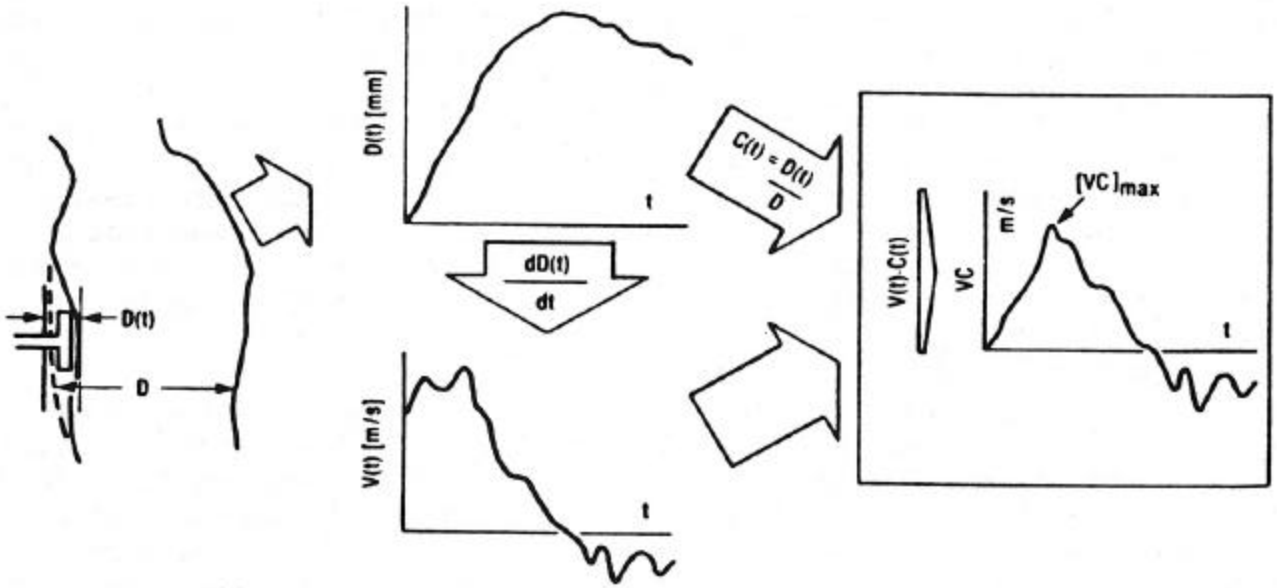
Input Parameters

- Projectiles
  - Materials
    - Compliant, Semi-Compliant, Semi-Rigid, Rigid
- Mass
- Velocity
- Kinetic Energy

Injury Parameters Studied

- Displacement
- Velocity of Displacement
- Viscous Criterion (VC)

Viscous Criterion



30g Baton vs. 100g Baton

- Constant Material (Semi-Rigid vs. Semi-Rigid)
- Lower mass, higher velocity vs. higher mass, lower velocity
- Constant Energy Density

Projectile	Mass (g)	KE (J)	Std. Dev.	Displacement (mm)	Std. Dev.	Velocity (m/s)	Std. Dev.	VC	Std. Dev.
PVC Baton	30	82.62	10.62	12.37*	1.00	7.31*	1.00	0.33*	0.09
PVC Baton	100	88.60	7.94	16.70*	1.48	9.44*	0.68	0.52*	0.07
* The mean difference is significant at the 0.05 level.									

30g Baton vs. 30g Wood

- Material (Semi-Rigid vs. Rigid)
- Constant mass and velocity
- Energy Density

Projectile	Mass (g)	KE (J)	Std. Dev.	Displacement (mm)	Std. Dev.	Velocity (m/s)	Std. Dev.	VC	Std. Dev.
PVC Baton	30	82.62	10.63	12.37*	1.50	7.31*	1.00	0.33*	0.09
Wood	30	90.52	6.07	15.51*	1.48	9.40*	0.68	0.52*	0.07
* The mean difference is significant at the 0.05 level.									

100g Baton vs. 100g Bean Bag

- Material (Semi-Rigid vs. Semi-Compliant)
- Constant mass and velocity
- Constant Kinetic Energy

Projectile	Mass (g)	KE (J)	Std. Dev.	Displacement (mm)	Std. Dev.	Velocity (m/s)	Std. Dev.	VC	Std. Dev.
PVC Baton	100	88.60	7.94	16.70	1.03	9.44*	0.80	0.58*	0.08
Bean Bag	100	86.74	7.72	14.09	2.46	7.23*	0.96	0.35*	0.11
* The mean difference is significant at the 0.05 level.									

XM1006 (29g vs. 58g)

- Material (Compliant vs. Compliant)
- Varying mass and impact velocity
- Energy Density

Projectile	Mass (g)	KE (J)	Std. Dev.	Displacement (mm)	Std. Dev.	Velocity (m/s)	Std. Dev.	VC	Std. Dev.
XM1006	29	81.73	7.83	6.84*	0.63	4.50*	0.69	0.15*	0.08
XM1006	58	88.88	6.76	8.91*	1.90	6.38*	1.43	0.21*	0.08
* The mean difference is significant at the 0.05 level.									

Conclusion

- Kinetic Energy and Energy Density alone not adequate predictors (input parameters)
- Higher mass = higher injury values
- Harder Material = higher injury values

Recommendation / Follow-On

- Expanded sample size
- Different Materials
- Different Kinetic Energies
- Penetration vs. Non-penetration

Questions or Comments

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